View metadata, citation and similar papers at core.ac.uk

brought to you by CORE

provided by Research Repository

A COMPENDIUM AND ANALYSIS OF ENERGY EFFICIENT NEW HOMES SUPPORT IN NORTH CAROLINA

Scott L. Hoover

MSc Renewable Energy (candidate)

BS Biology

School of Engineering and Energy

Murdoch University

2012

DECLARATION

This Dissertation is my own account of my research, except where other sources are appropriately acknowledged. Any errors are my own.

Scott L. Hoover

ABSTRACT

The growth of the energy efficient new homes market in North Carolina has largely been through free market demand. However, greater energy efficiency savings and increased market penetration of these homes will be necessary to mitigate climate change. This dissertation creates a compendium of the resources supporting market penetration of energy efficient new homes. Resources are identified whether they contribute directly to the industry such as utility incentives, or indirectly such as the educational institutions building the necessary workforce. Resources include federal and state government, private and non-profit enterprise, industry organizations, and their policies, incentives, and other influences. The drivers and barriers to energy efficient homes gaining market share in North Carolina are identified and conclusions are drawn about what can contribute to greater adoption of energy efficient homes in North Carolina. The findings show that North Carolina is resource rich but policy poor. Many strong organizations are poised to support the industry, but the policies and incentives needed to move the industry forward are not in place. Energy efficiency has taken a back seat to renewable energy. However, policies that have been influential in the past, such as building energy codes and utility incentive programs have recently been strengthened. The influence of this strengthening on energy efficient new homes remains to be seen. The Renewable Energy and Energy Efficiency Portfolio Standard (REPS) appears to be a significant driver of renewable energy and to a lesser extent energy efficiency. However, the energy efficiency portion of the REPS is weak compared to other states and should be strengthened. In addition, new policies are needed that value energy efficiency on an even footing with renewable energy.

TABLE OF CONTENTS

ABBREVIATIONS

AEEREP	Association of Energy and Environmental Real Estate Professionals
ASHRAE	American Society of Heating, Refrigeration, and Air Conditioning Engineers
ASU	Appalachia State University
CDD	Cooling Degree Day
CSF	Conditioned Square Foot
EERS	Energy Efficiency Resource Standard
EPA	Environmental Protection Agency
ESNH	Energy Star for New Homes
GHBT	Green Home Builders of the Triangle
HBA	Home Builders Association
HDD	Heating Degree Day
HERO	High Efficiency Residential Option
HPH	High Performance Home
IECC	International Energy Conservation Code
L&A	Lights and Appliances
LBE	Lead by Example
MLS	Multiple Listing Services
NAHB	National Association of Home Builders
NC	North Carolina
NCEEA	North Carolina Energy Efficiency Alliance
NCSC	North Carolina Solar Center
NCSEA	North Carolina Sustainable Energy Association
NCSU	North Carolina State University
NHPC	National Home Performance Council
NZE	Net Zero Energy
PV	Photovoltaic
RPS	Renewable Energy Portfolio Standard
REPS	Renewable Energy and Energy Efficiency Portfolio Standard
RNC	Residential New Construction
ZEC	Zero Energy Capable
ZEHE	Zero Energy Home Envelope

ACKNOWLEDGMENTS

Heartfelt thanks go to Dr Trevor Pryor for acting as my dissertation advisor. Thanks to my wife, Chutikan, and son Alex for being my motivating force. Thanks also to Amanda Huber for being my writing coach and to Tish Hoover and Kim Ashley for their support. In memory of my dad, Norm Hoover.

1. INTRODUCTION

1.1 SCOPE AND PROBLEM

The energy consumption of just the buildings in the United States alone is greater than any other country's total energy consumption except China and the whole of the United States. Put another way, if the U.S. built environment were considered as a separate nation, it would rank third in energy consumption. U.S. homes represent about half of the built environment's energy consumption. (Lovins, Amory B. and Rocky Mountain Institute 2011) With the vast majority of the United States' 115 million homes being net energy consumers, there is huge potential for reducing energy consumption in American homes through energy efficient and Net Zero Energy (NZE) homes.

North Carolina is no exception to the national numbers. In 2011, North Carolina had the twelfth highest overall energy consumption in the nation at 2,545.4 Trillion BTUs/yr. North Carolina's residential sector ranked tenth in the nation in energy consumption at 712.3 Trillion BTUs/yr- a 3.4% share of the U.S. residential energy use. North Carolina is located in the southeast United States on the Atlantic coast. It had an estimated population of 9.6 million in 2011 and 4.3 million total housing units in 2010. (U.S. Census Bureau 2012)

In 2011, North Carolina added about 53,000 new housing units. Although new housing units are a fraction of the total number of homes in the state, there is good reason to focus on energy efficiency in new construction. New construction is the best opportunity to lock in energy savings for the long term. New construction offers unlimited opportunities for efficiency options, whereas retrofits are limited based on the existing structure and level of retrofit. In addition, energy retrofits are difficult

and expensive and therefore not attractive to home owners. Before turning attention to the more difficult task of energy efficiency in existing homes, the hemorrhaging of energy from new construction needs to be stopped.

1.2 BACKGROUND AND PURPOSE

Not too long ago, a home with reduced air infiltration, added insulation, and double paned windows would have been considered energy efficient. This reduction in energy use was applauded and these efficient homes were available on the market for the potential homebuyer. Over time, many of these features have become standard in new construction. Energy efficient homes standards are constantly being redefined to represent significant energy savings over current code. However, Net Zero Energy homes, a rarity, have mainly been found in a research setting, as a demonstration home, or built by passionate first adopters. In the spectrum between "built to code" and Net Zero Energy homes, there is a continuum of efficiency levels. Nowadays, Net Zero Energy (NZE) homes are starting to move beyond the demonstration stage toward market readiness.

As energy efficient homes gain market share (about 20% of new homes in 2011) and as NZE homes move from demonstration to the market, the focus shifts from identifying construction and design best practices to identifying the barriers and drivers to market penetration. The purpose of this study is to create a compendium of the support for market penetration of energy efficient homes in NC, thereby answering the questions: What are the drivers and barriers to energy efficient homes gaining market share in North Carolina? What can contribute to the greater adoption of energy efficient homes in North Carolina?

1.3 The Energy Efficiency Continuum

As mentioned, new energy efficient homes lie along a continuum (see Figure 1). (Farhar 2008)

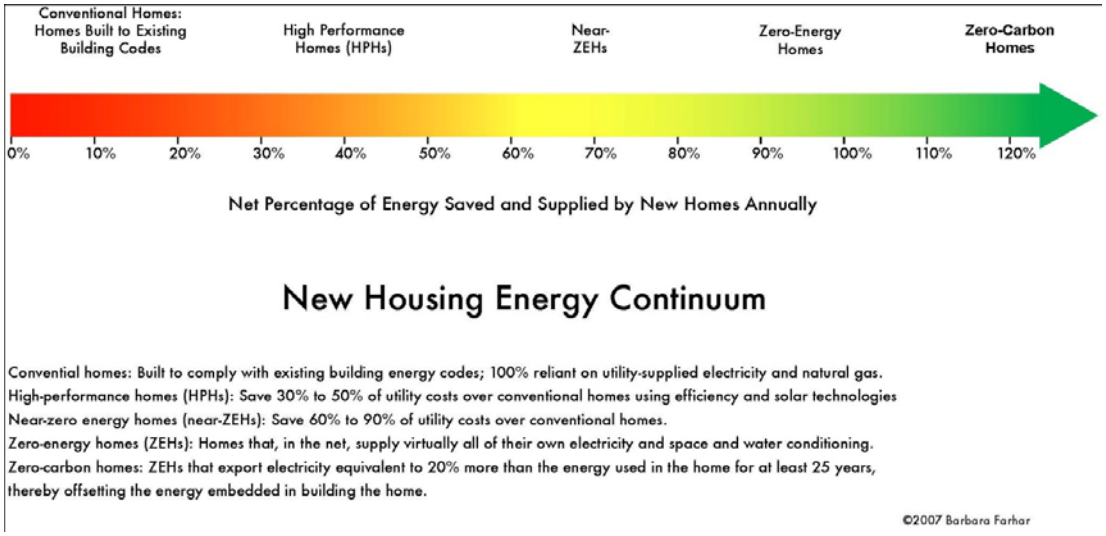

Figure 1: New Housing Energy Continuum (Farhar 2008)

On the one end are homes built to current codes. These homes can be described as the worst home allowable by law, or barely legal homes. At the opposite end of the spectrum are zero-energy (also called net zero energy) and zero-carbon homes. An net zero energy (NZE) home "produces as much energy as it uses on an annual basis. This includes energy for heating, cooling, and all the devices that plug into the wall. Net zero houses are typically connected to a local electric utility. They use the grid for storing excess electricity generated by photovoltaic panels or a wind turbine, banking electricity at times of plenty and drawing on the surplus when production falls." (Johnston and Gibson 2010) Zero-carbon homes produce more energy than they use on an annual basis to offset the energy embodied in the materials and construction of the home. In between the two ends, there are a host of terms used to describe energy efficient homes. Michael Maines puts forth the idea of the 'Pretty Good House'. "The idea of the Pretty Good House is to find the sweet spot between expenditures and gains. When is enough insulation enough?" (Maines 2012) Other terms include High Performance Homes (HPHs), solar ready homes, near zero

energy homes, zero energy capable homes, and others. Throughout this paper, energy efficient homes will refer to homes all along the continuum of efficient homes. Other terms are also used in the paper, and their usage generally refers to the continuum of efficient homes. It should be obvious from context whether a term is referring to just a portion of the continuum. Net Zero Energy as used in this paper is in terms of site energy: energy consumed or produced at the home.

The HERS index is a common method of rating a home's energy use in the United States (Randazzo 2012) The Residential Energy Services Network (RESNET) Standards (RESNET 2012) promulgate the use of the HERS index (Figure 2). The HERS index is a scale on which 100 is benchmarked to the IECC 2006 code. (RESNET 2012) Older existing homes average about HERS 130. New homes built under codes slightly exceeding IECC 2006 code index around HERS 85 to 90. A HERS index of 40 or lower would certainly fall under the label of a high performance home. A Net Zero Energy home would index at HERS 0. Negative HERS index are also possible such as for zero-carbon homes.

Figure 2 HERS Index promulgated by RESNET (RESNET 2012)

1.4 Review of Methods

This research is conducted as a review of literature, creating a digest of influences on energy efficient homes such as building codes, incentive structures, programmatic approaches, case studies, government policy, and utility efforts, as well as non-profit, private, and governmental organizations.

1.5 North Carolina Climate

In any consideration of home energy use, it is important to consider the climate where the home is located. North Carolina is comprised of three distinct geographic areas: the Coastal Plain in the east along the Atlantic Ocean, the Piedmont in the central region, and the Mountains in the west. North Carolina has one of the most varied climates of the eastern states due in part to its varied geography. Temperature differences across the state during all seasons averages 20° F from the low coastal region to the mountains. The minimum lowest temperatures are from 0° to 30°F (-17.8° to -1.1° C). The average daily maximum reading in midsummer is below 90° F for most localities. Average annual precipitation east of the mountains is between 45 and 55 inches. (State Climate Office of North Carolina n.d.) The IECC 2009 climate zones (Mapawatt 2010) falling within North Carolina is illustrated below.

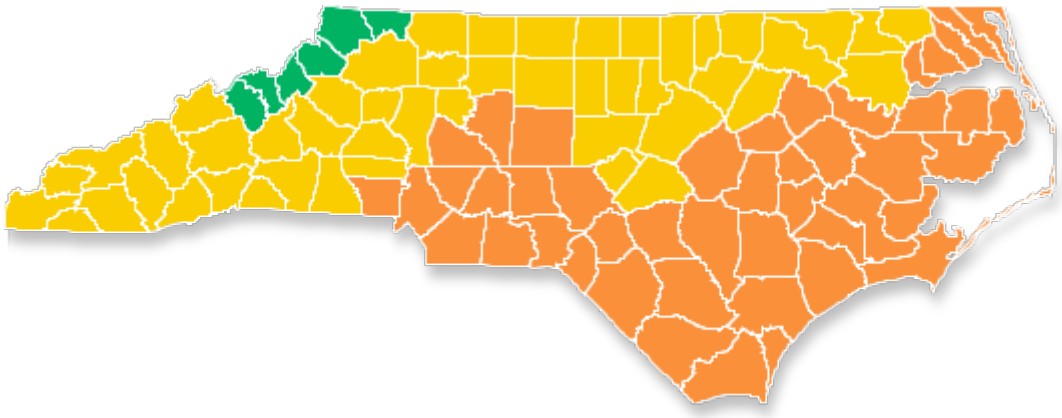

Figure 3 IECC climate zones falling within North Carolina: orange=zone 3A, yellow=zone 4A, green=zone5 (U.S. Department of Energy n.d.)

Climate zones are further subdivided into moisture zones. All of North Carolina is categorized as moist (designated by an A along with the zone number) averaging between 40 and 55 inches across most of the state. The following table, Table 1, is useful in defining the temperature variations, in heating degree days and cooling degree days, of the various climate zones across the U.S. and Canada, including North Carolina. (Mapawatt 2010)

TABLE 301.3(2)
INTERNATIONAL CLIMATE ZONE DEFINITIONS

ZONE NUMBER	THERMAL CRITERIA	
	IP Units	SI Units
1	9000 < CDD50°F	5000 < CDD10°C
2	6300 < CDD50°F ≤ 9000	3500 < CDD10°C ≤ 5000
3A and 3B	4500 < CDD50°F ≤ 6300 AND HDD65°F ≤ 5400	2500 < CDD10°C ≤ 3500 AND HDD18°C ≤ 3000
4A and 4B	CDD50°F ≤ 4500 AND HDD65°F ≤ 5400	CDD10°C ≤ 2500 AND HDD18°C ≤ 3000
3C	HDD65°F ≤ 3600	HDD18°C ≤ 2000
4C	3600 < HDD65°F ≤ 5400	2000 < HDD18°C ≤ 3000
5	5400 < HDD65°F ≤ 7200	3000 < HDD18°C ≤ 4000
6	7200 < HDD65°F ≤ 9000	4000 < HDD18°C ≤ 5000
7	9000 < HDD65°F ≤ 12600	5000 < HDD18°C ≤ 7000
8	12600 < HDD65°F	7000 < HDD18°C

For SI: °C = [(°F)-32]/1.8.

Table 1 IECC climate zone definitions in Cooling Degree Days (CDD) and Heating Degree Days (HDD). Climate zones extend from southern Florida and Hawaii (zone 1) to northern Canada and Alaska (zones 7&8) (Mapawatt 2010)

1.6 Review of Principal Findings

There are numerous resources identified that influence energy efficient new home markets in North Carolina. Many of these resources contribute in an indirect way such as North Carolina's Lead by Example program which both showcases projects and creates a market for efficient building products and services. Other resources have a more direct influence on the industry. The ENERGY STAR program, with its brand recognition, and utility incentives have directly contributed to increasing numbers of energy efficient homes. In addition, there are overarching ideas that show promising contributions that affect the whole industry- not just in North Carolina. Among them are technological advances in windows, engaging people through real-time energy consumption data, and a growing demographic of home buyers who prioritize quality in their homes.

The Findings are structured first by overarching ideas. Next, government support, both at the federal and state level, is covered. Then, trade and industry organizations

involved in new home energy efficiency are covered. Private enterprise and then educational institutions round out the discussion of the Findings. Discussion, conclusions, and recommendations follow the Findings section.

1.7 Review of Principal Conclusions

The new homes energy efficiency industry in North Carolina appears to be resource rich and policy poor. Many strong organizations are poised to support the industry, but the policies and incentives needed to move the industry forward are not in place. Energy efficiency has taken a back seat to renewable energy. However, policies that have been influential in the past, such as building energy codes and utility incentive programs have recently been strengthened. The influence of this strengthening on energy efficient new homes remains to be seen. In addition, to strengthening existing policies, new policies should be developed that place energy efficiency on an even footing with renewable energy in the state.

2. REVIEW OF PREVIOUS WORK

The literature review for this research paper is spread throughout the dissertation. An overarching view of the efficient homes industry in North Carolina - with as much detail included - has not been found. This paper is intended to contribute to the field to provide a summary and synthesis of relevant information concerning the market penetration of energy efficient new homes in North Carolina.

3. DESCRIPTION OF THE RESEARCH DESIGN

Research for this dissertation was primarily desktop search of resources on the internet. In addition, books, periodicals, and journals were referenced. The research amounts to a literature review, or more accurately, a synthesis of actors and support around efficient new home construction in North Carolina. It is not intended to be a definitive listing of all companies, organizations or policies supporting efficient home market penetration in North Carolina. The research was done in the following stepwise fashion:

- Review of literature: To determine if such a comprehensive undertaking had been undertaken in the past, I performed internet searches of energy clearinghouses in NC that were known through my involvement in the new homes industry. The search was then expanded to a general internet search.
- As footwork for future research, I studied several books by individuals whom I consider visionaries in the field (Amory Lovins and Sam Rashkin) along with several other books
- Drawing on five years of hands-on work and experience in the energy efficient new homes industry in North Carolina, I identified all actors and support for energy efficient new home construction in North Carolina known to me.
- Research into these known organizations then led to additional resources in an expanding fashion. Any organization, institution, policy, or incentive, building program or other factor that might touch or influence new home construction in North Carolina was considered for inclusion.
- Several sites were found to be invaluable and much of the content was drawn from these sites. For example, the research from the NCSEA's Industry

Census led to much of the content in the Private Companies section of the results.

- Research was expanded to a general search. Research was primarily internet searches; however, extensive use was also made of an EPA branch library and the main library and design libraries of NC State University.
- Much of the Introduction was written early to try to frame the subsequent findings and provide adequate background. Much of it was edited later as a result of scope creep. The introduction was also designed for an Australian audience. For example, a greater description of North Carolina climate and weather was included than might have been otherwise.
- Once a solid foundation was established, the results were organized into the final format found in the Findings section. Realizing that some topics transcended North Carolina or affected the housing industry as a whole, an Overarching Themes section was included.
- Once the framework was in place, the sections were completed piecemeal from the resources identified.

4. FINDINGS

4.1 OVERARCHING THEMES

4.1.1 CHANGING DEMOGRAPHICS AND MARKET

In 2007, the U.S. housing industry crashed, dragging the entire economy with it. (Rashkin 2012) The housing industry had experienced unprecedented growth since 1990. However, in order to attract ever more homebuyers, lenders had turned to creative financing schemes such as subprime loans which provided mortgages to buyers who could not provide a down payment, had no documentation of work history or adequate income, or had poor credit scores. These loans soon experienced massive defaults and the housing crisis began. The housing crisis - along with a changing demographic - has changed the landscape of the housing industry. NZE homes must be considered against this landscape. Sam Rashkin (Rashkin 2012) has identified some of these critical changes that constitute the new normal of new home construction:

- Smaller universe of qualified buyers
- More competition from low-priced used homes
- Urban centers becoming more geographically desirable
- Increasing perception that homeownership is no longer compelling
- A protracted economic recovery

Advocates of New Urbanism and co-housing are promoting smart growth communities to combat sprawl. These communities are characterized by higher density, discernible community focal points, short walks to work or shopping, mixed commercial and residential use, and access to mass transit. (Rashkin 2012) Homebuyers are increasingly moving to urban areas and areas of New Urbanism in search of community and connection. They are also living with less space. The size

of the average new construction home has decreased since the beginning of the housing crisis. (Rashkin 2012) A right sized home can feel spacious if effective design techniques are used.

The next generation of home buyers will be technologically savvy homebuyers and will expect a degree of technology integrated into their homes. (Rashkin 2012) Although many of the practices leading to NZE homes are not technologically riveting (think insulation), much of the emerging technology discussed in other sections of this paper will appeal to the Gen X and Gen Y population. Technical advances in communication and connectivity have changed how people communicate with each other and the devices we use. As will be seen later in this Findings section, modern methods of communication make it possible for previously unprofitable utility efficiency programs to now return a profit.

Housing markets will need to adapt to an aging baby boomer consumer as well as Gen X and Gen Y consumers. There are around 76 million boomers. Market studies have shown that baby boomers are looking for smaller, low maintenance homes in urban centers where they can age in place. (Tomasulo 2009)

A decidedly low-tech way of influencing behavior without using force or incentives is called “Nudging”. (Jespersen 2012) Nudge tactics employ behavioral psychology to influence behavior. Typically, no new information or options are presented, but by offering salient information to people at the time it is needed, they can make better informed decisions. When applied to how we interact with our homes and consume energy, there is opportunity to inform better decisions about when or how homeowners operate their home. Monitoring energy consumption, calculating the

energy cost, and presenting the data to homeowners can lead to conservation. (Lovins, Amory B. and Rocky Mountain Institute 2011) There are numerous devices and sites on the market that give consumers access to their energy usage and cost. The Wattson is one example of a device that can 'nudge' homeowners to conserve energy. (Jespersen 2012) It looks like an ordinary clock, but displays the energy usage in real time and calculates the cost. This information gives the consumer an idea of how much an appliance, such as an air conditioner, costs to use. Should users begin to ignore the clock, it can be programmed to glow blue for low energy use, purple for average energy use, or red for high energy use. From this author's personal experience, utilities have been hesitant to implement concepts which depend on behavior modification because the behavior can always revert back and is not guaranteed. However, some devices, such as the Wattson clock claim energy use reduction of 25%.

4.1.2 APPROACHES TO NZE HOMES

One approach to achieving a NZE home would be to simply add renewable energy to a poorly or standard insulated home until the electricity consumption is offset by the renewable energy production. This is seldom the best approach. The cost of most renewable energy production devices would have to fall dramatically to make this a cost competitive option to energy efficiency. Alternatively, energy conservation and efficiency could cut the demands so that it is not necessary to supply so much energy. Energy Conservation and renewable energy supply must be treated on an equal footing. (Everett 2004) The high cost of renewable energy (whether paid for by government subsidies or the energy user) is ultimately a drag on economic growth, whereas money spent of efficiency reduces costs over time. (Gunther 2012)

Passive solar homes typically are thought of as homes which incorporate the following essential design: (Everett 2004)

- Large area of south facing (north facing in the southern hemisphere) windows to collect sunlight
- Lots of thermal mass in the building to store the thermal energy during the day and slowly release it over the night.
- Heavy insulation in the rest of the structure to retain the heat.

However, early experiments in this type of passive home resulted in homes that overheated during the day and were cold at night- usually because of too much glazing or not enough thermal mass. There are other design approaches that could be considered passive which don't necessarily require passive solar orientation or large glazing areas. As we will see later in this paper, the Passive House Standard relies more on super-insulation than proper orientation and thermal mass. It does not, in fact, require passive solar practices in its requirements, though many Passive Houses do incorporate them. There are many different design approaches to high efficiency homes. As Bob Everett states, "The art of design… is to understand the energy flows in a building and make the most of them." (Everett 2004)

4.1.3 EMERGING TECHNOLOGY

Since appliance efficiency standards were introduced in 1978, 7% of U.S. electricity has been saved. (Lovins, Amory B. and Rocky Mountain Institute 2011) In the years and decades to come, emerging technologies have the potential to make NZE homes more easily achievable and at a reduced cost. In a 2010 survey, 51% of building managers thought lighting technologies would have the largest performance-to-price ratio improvement in the coming decade- 44% thought the same for smart building technology and 38% for solar panels. (Johnson Controls and International Facility

Management Association 2010) Amory Lovins describes a few of these emerging technologies (Lovins, Amory B. and Rocky Mountain Institute 2011) as follows:

- Aerogels and Nanogels: silica based gels that insulate up to R-40 per inch.
- Windows: advanced windows alone are expected to reduce a typical house's heating and cooling energy use by up to 30%. New windows will be able to vary the amount of incoming heat energy depending on the temperature of the outside pane of glass, allowing five times more solar heat inside on a cold winter day than on a hot summer day.
- Thermal Storage Materials: phase-change materials imbedded in building materials to store heat and prevent the buildup of heat in a house during the day.

One clear direction in approaching net zero energy homes is what could be called a multiple use of components strategy. For example, when building and designing his ultra efficient home in 1984, Amory Lovins, Co-founder, Chairman, and Chief Scientist at Rocky Mountain Institute, specified no less than 12 uses (structural support, thermal mass, shading…) into the large archway spanning the atrium (Yi, Ramirez and Bendewald 2010). Structural siding, weather resistant barrier, exterior continuous foam board insulation, and cladding once were all installed in separate applications to homes and each served one function. Products appeared which then combined two of the components: cladding and insulation, structural siding and insulation, structural siding and weather resistant barrier, insulation and weather resistant barrier. A new product on the market turns the dial from two to three, combining structural siding, continuous insulation (R3.6 or R6.6), and a weather resistant barrier. Multiple use components save on labour costs. With multiple use

components says Amory, “You'll get many benefits from each expenditure and your building will work better, be a nicer place to live, and cost less." (Cohen 2008)

4.2 GOVERNMENT

4.2.1 FEDERAL

The Energy-Efficient New Homes Tax Credit for Builders was the only federal incentive for high performance new homes through the end of 2011. The incentive was a $2000 corporate tax credit for builders of homes in which the heating and cooling energy consumption was reduced 50% with no less than one-fifth of the consumption reduction coming from envelope improvements. (DSIRE 2012) The tax credit has been in effect since 2005, but has intermittently expired and then been reinstated. It most recently expired at the end of 2011 and has not yet been reinstated. While building codes have been updated in the years since the credit was first introduced, the tax credit has not. Therefore, the credit does not amount to as meaningful a reduction in energy consumption as compared to the updated code homes.

The federal Department of Energy’s Residential 30% Codes Initiative has provided the important and challenging goal of achieving a 30% increase in residential energy savings in the 2012 IECC over the 2006 IECC baseline. The 2009 IECC is estimated to achieve 12 to 15% improvement in energy savings. (U.S. Department of Energy Building Energy Codes 2011) As we will see, North Carolina’s code uses the 2009 IECC as a basis for its current 2012 code. Therefore, this initiative has important consequences for North Carolina.

There are numerous residential building efficiency programs under the Department of Energy with an indirect contribution to NZE houses in North Carolina: Better Buildings, Emerging Technologies, and Building Energy Codes. Two worth noting are the DOE's Builder's Challenge and Building America Program.

The Builder's Challenge program builds off of the ENERGY STAR New Homes program (discussed elsewhere in this paper). In addition to meeting all the requirements of the ENERGY STAR for New Homes program, to meet Builder's Challenge homes must also meet these additional criteria: (U.S. Department of Energy 2012)

- Install ENERGY STAR labeled appliances and fixtures
- Install ENERGY STAR windows
- Meet IECC 2012 insulation levels
- Install HVAC air distribution ducts within conditioned space
- Employ efficient hot water distribution system
- Comply with EPA Indoor airPLUS specifications
- Meet the criteria for EPA Renewable Energy Ready Home (RERH) for solar electric and solar thermal applications

Homes meeting Builder's Challenge are 40% to 50% more efficient than a typical new construction home. This equates to a HERS index in the 50s. At this level, renewable energy systems could cost-effectively meet the residual loads.

The Building America program offers its own specifications for a 50% more efficient home. The Building America program "is an industry-driven, cost-shared research program working with national laboratories and building science research teams to accelerate the development and adoption of advanced building energy technologies

and practices in new and existing homes." (Building America 2011) Using best available technology and Zero Energy Home Envelopes (ZEHE), Building America has set climate specific criteria for a 50% more efficient home. (Anderson and Roberts 2008) Additionally, building America is researching new technology and systems for an additional 40% energy reduction (relative to the 50% reduction) to achieve NZE homes with a neutral cost by 2020. Zero Energy Home Envelopes are a compelling proposition. As Anderson and Roberts state, (Anderson and Roberts 2008) "Envelope systems are difficult and expensive to replace after initial construction. The impacts of initial design decisions are felt for 50-100 years after construction. Current U.S. energy codes do not target the most cost effective insulation levels based on homeowner energy costs and financial risks."

North Carolina is home to many federal military bases and lots of military housing. The Pentagon looks at climate change as a "threat multiplier." (ClimateBites n.d.) It views war as likely fallout of climate stresses, such as displacement of peoples due to shortages in land, water, and agriculture. Therefore, the DOD invests heavily in R&D of renewable energy. Just as advanced technology such as the internet and Global Positioning Systems came out of military research and applications, so could advances in renewable energy, NZE homes, and smart grid technology. However, the efforts of the military have been hampered recently when the Senate Armed Services Committee voted 13 to 12 to forbid the purchase of any alternative fuel costing more than traditional fossil fuels. (Lovins 2012) This mindset could be detrimental to the advancement towards NZE homes by removing the "demand pull" created by the construction of high performance homes.

North Carolina is home to the Marine Corps' first net zero energy home. Located at their Camp Lejeune base in Jacksonville, the home was built as a case study for the Navy and the contractor. (Atlantic Marine Corps Communities n.d.) Lessons learned and best practices from the project will inform future NZE projects. The marine's NZE home is part of a larger military community of 537 LEED Gold certified homes under construction. Because of the sheer number of military housing units in North Carolina, the military's commitment to 'alternative' buildings such as NZE and LEED certified buildings could advance the energy efficient building industry in North Carolina.

With a few exceptions, support for energy efficiency and renewable energy in the United States has typically been left to the individual states with little federal policy. (American Wind Energy Association 2011) While fossil fuels benefit from stable and consistent policies, the policies and incentives that the federal government have enacted for energy efficiency and renewable energy typically face expiration every year or two and uncertainty that they will be extended. This does not encourage long term planning, investment, and support. As expiration dates near, lenders hesitate to provide capital for projects, there are increased layoffs, and projects are rushed to finish before incentives expire. (American Wind Energy Association 2011) A prime example would be the Production Tax Credit (PTC) which supports wind, biomass, and geothermal utility scale electricity generation.

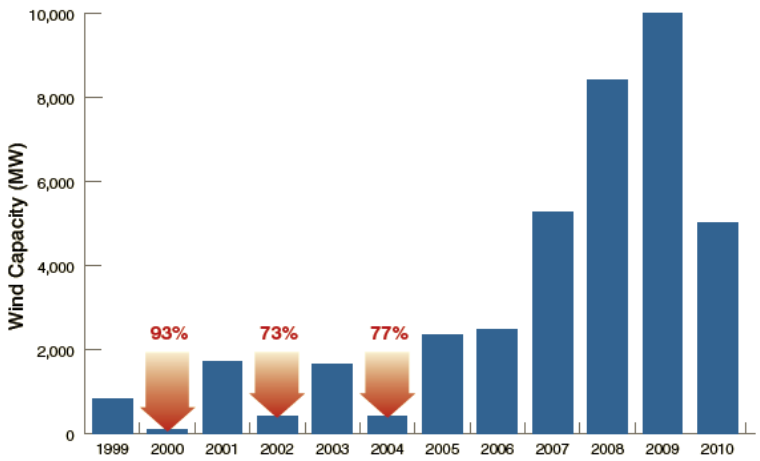

Figure 4 A lack of stable policies creates a boom-bust cycle for wind and other sustainable energy sources. (American Wind Energy Association 2011)

Likewise, similar ‘boom and bust’ effects have been seen with the Energy-Efficient New Homes Tax Credit for Builders.

Through Executive Orders signed by the President of the United States, the Federal Government has supported energy efficiency and renewable energy through leading by example. The 2009 Executive Order 13514 “Federal Leadership in Environmental, Energy, and Economic Performance” requires that all new federal buildings must be designed to achieve “zero net energy” by FY 2030, starting in FY 2020. (U.S. Environmental Protection Agency 2011) Lead by example (LBE) programs support the proliferation of NZE homes by creating markets for new building products and practices, by driving down costs through economy of scale, and by demonstration of workable solutions.

Homes qualified to meet the current ENERGY STAR for New Homes (ESNH) guidelines are at least 15% more efficient than homes built to 2009 IECC code. (ENERGY STAR n.d.) Although this degree of efficiency does not come near net zero energy, it is an important stepping stone on the path to net zero. Nearly 11,000 new homes were qualified in North Carolina under the program in 2011, a market penetration of between 12 and 24%. (ENERGY STAR n.d.) ENERGY STAR is a joint program of the U.S. Environmental Protection Agency and the U.S. Department of Energy. The ENERGY STAR label is the most widely adopted and recognized energy efficiency label in North America. There are labels for household products and home improvement products as well as for new and renovated homes. Many green building certification standards incorporate ENERGY STAR guidelines (in whole or in part) within the green standard. Examples include the LEED for Homes program and EarthCraft House guidelines.

The current guideline (ENERGY STAR v3.0) consists of core requirements and compliance with four checklists: (ENERGY STAR n.d.)

- Thermal Enclosure System Rater Checklist
- HVAC System Quality Installation Rater Checklist
- HVAC System Quality Installation Contractor Checklist
- Water Management System Builder Checklist

The basic core requirement is that the home achieves a certain minimum level of efficiency based on the HERS Index- typically between HERS 65 and 75. This target can be achieved either through computer performance modeling (allowing a customized package of improvements), or a predefined prescriptive set of improvements. The checklists ensure that the integrity of the home is upheld through quality installation of insulation, air barriers, heating and cooling equipment, and the water drainage plane (roof, walls, foundation, and site).

ENERGY STAR for New Homes guidelines recently underwent a revision that is only now taking full affect. From the author's experience with the program, the current version of the guidelines described above has been criticized as too rigorous, complicated, and over reaching by some builders. Many object to the inclusion of requirements that at first appear outside the realm of energy efficiency such as the requirement for water managed roofs, walls, foundation, and site.

4.2.2 NORTH CAROLINA

As noted earlier, Lead by Example (LBE) programs are an important way for NZE homes to gain popularity and market acceptance. At the state level, North Carolina's LBE program is the Sustainable Energy-Efficient Buildings Program. It calls for

energy consumption reduction by 30% from ASHRAE 90.1 2004 levels in all new buildings of state agencies and state institutions of higher learning. (North Carolina General Assembly n.d.) However, with adoption of stricter energy codes in 2012, the current codes have caught up with the Sustainable Energy–Efficient Buildings Program standards. Next year's program report may contain recommendations for raising the efficiency of state projects to exceed code. It is also a priority of NC's LBE program to use North Carolina based resources, building materials, manufacturers, and businesses to provide economic development to the state and advance the energy efficient buildings industry locally. (North Carolina General Assembly n.d.)

The State Energy Office oversees several programs mainly concerned with distribution of federal and state funds and grants- and administers several state programs such as North Carolina's Lead by Example program discussed above. It has little direct involvement with the new home industry other than allocation of funds.

Buoyed by a federal energy grant late in 2008, North Carolina set out to develop building codes for the next code cycle (effective in 2012) to save fuel and $40 million yearly. The initial proposal was to meet DOE's 30% Residential Codes Initiative. (Easley 2008) Had this goal been achieved, North Carolina would have had one of the most stringent state energy codes in the United States. However, as the Code Council met to approve the new code, there was opposition and only after the NC Legislature interjected, a compromise code was negotiated. The compromise code, which took effect March 1, 2012, is about a 15% savings in residential energy as compared to the 2006 IECC. (Mathis 2011) While not as strict as initially

proposed, the code does have some substantial strengthening amendments that equal or exceed the 2009 IECC on which it is based such as required duct leakage performance testing and R15 insulation levels in the walls.

The initially proposed 30% goal was, however, retained in the code as a 'stretch code'- a voluntary option called the Home Efficiency Residential Option (HERO). Through this prescriptive option, builders can achieve a home that is 30% better than North Carolina's past code. (Mathis 2011) It is thought that the HERO would be used as the basis for incentives such as tax credits, utility incentives, mortgage incentives, and others. These incentives act as further market drivers for high performance homes and advance the march towards NZE.

North Carolina offers several incentives for efficient home appliances and equipment including a Sales Tax Holiday for Energy-Efficient Equipment. (DSIRE 2012) North Carolina does not offer many incentives for market rate NZE or other high performance home construction other than a few 'local options'-which allow local jurisdictions the right to offer certain incentives- and a Renewable Energy Tax Credit which contains some eligible passive solar technologies. (DSIRE 2012) North Carolina does, however, have an array of incentives aimed at renewable energy generation. (Harkrader Fall 2005) Along with the State's 35% Renewable Energy Tax Credit for residential renewable energy generation systems, there are additional incentives. (DSIRE 2012)

When a home is unable to achieve Net Zero Energy through efficiency measures, the purchase of renewable energy offsets can get it there through green power generation offsets. North Carolina's offset program is called GreenPower. (NC GreenPower

n.d.) The goal of NC GreenPower is to supplement the state's existing power supply with more green energy – electricity generated from renewable energy sources like the sun, wind, and organic matter. NC GreenPower is an independent, nonprofit organization operating on voluntary contributions toward renewable energy and the mitigation of greenhouse gases. A landmark initiative approved by the N.C. Utilities Commission, NC GreenPower is the first statewide green energy program in the nation supported by all the state's utilities and administered by Advanced Energy, an organization discussed elsewhere in this paper. (NC Sustainable Energy Association 2012) NC GreenPower pays homeowners Renewable Energy Certificates (RECs) for clean generation such as PV used to offset energy use.

Shortly after NC GreenPower and simplified interconnection standards for distributed generation were established, Net Metering was approved in North Carolina. (Harkrader Fall 2005) Net Metering in NC allows small renewable energy generators – up to 20kW for residential- to connect to the grid and then generate and 'store' excess generated energy on the grid for later use. Excess summer energy production is paid at avoided cost rates and the RECs on the excess (paid by NC GreenPower) are donated to the utility. As battery storage systems are expensive, Net Metering allows net zero energy homes to be achieved much more affordably.

In 2007, NC adopted its version of a renewable energy portfolio standard (RPS) called the Renewable Energy and Energy Efficiency Portfolio Standard (REPS). Investor Owned Utilities are required to supply 12.5% of their retail electricity sales from eligible sources by 2021. (NC Sustainable Energy Association 2012) Eligible sources include solar electric, solar thermal, wind, biomass, and others. In addition to these more traditional renewable energy sources, the NC REPS is unique in that it

also allows a portion of the requirement (25%) to be met by reducing energy consumption through the implementation of utility-sponsored energy efficiency measures. An "energy efficiency measure" means an equipment, physical, or program change that results in less energy used to perform the same function. "Energy efficiency measure" does not include demand-side management. While other states have initiated separate Energy Efficiency Resource Standards (EERS), North Carolina has rolled their EEPS within a renewable portfolio standard. The NC REPS may be the motivation behind some of the efficiency programs discussed under the 'Utilities' section in this paper.

4.3 TRADE AND INDUSTRY ORGANIZATIONS

4.3.1 NATIONAL ASSOCIATION OF HOME BUILDERS

The National Association of Home Builders (NAHB) promulgates the National Green Building Program, a green building standard that uses the ENERGY STAR program as its energy efficiency basis. The Green Home Builders of the Triangle (GHBT) is a joint program of two NC Home Builder Associations (HBA). The GHBT promotes the growth of the building industry while advocating concern for the environment.

4.3.2 NC SUSTAINABLE ENERGY ASSOCIATION

The NC Sustainable Energy Association (NCSEA) informs policy and champions much of the legislation that has set North Carolina apart as a leader in renewable energy supportive regulations. NCSEA is a nonprofit membership organization of individuals, business, government, and non-profits interested in North Carolina's sustainable energy future. (NC Sustainable Energy Association 2012) NCSEA also

provides education and economic development of the energy efficiency and renewable energy industries.

4.3.3 NC ENERGY EFFICIENCY ALLIANCE;

The North Carolina Energy Efficiency Alliance (NCEEA) is a non-profit collective of organizations and businesses working to stimulate the market for energy efficient construction throughout the state. (NC Energy Efficiency Alliance 2012) Through education and promotion of energy efficient homes, the organization aims to address market barriers in the home building industry. The Alliance focuses on home energy raters, architects, developers and builders, real estate agents, appraisers, mortgage lenders, and homebuyers. Alliance members include Appalachian State University, The State Energy Office, Advanced Energy, The NC Solar Center (all organizations discussed elsewhere in this paper,) and Southern Energy Management - a renewable energy and energy efficiency services company based in North Carolina.

4.3.4 ADVANCED ENERGY;

Advanced Energy is another non-profit working to advance energy efficiency and renewable energy in North Carolina. (Advanced Energy 2012) Besides administering North Carolina's GreenPower program (discussed elsewhere). Advanced Energy also runs the SystemVision program. SystemVision standards are a set of energy efficiency building standards for non-profit builders such as Habitat for Humanity. (Advanced Energy n.d.) More than 45 non-profit builders in North Carolina take advantage of the program. The SystemVision program offers a guarantee on heating and cooling energy used and on room temperature- few programs in the United States offer such a guarantee. Advanced Energy also conducts research, consultation, and training.

4.3.5 PASSIVE HOUSE STANDARD

Although there are only a handful of Passive House Certified homes in North Carolina, the program is gaining popularity and has name recognition. At least one builder in North Carolina, Anchorage Building Corp, has embraced the program. (Anchorage Building Corp 2012) The program has its origins in Germany (Passivhaus in German) and has since been taken up elsewhere around the world. The criteria for the Passive House Standard are as follows (polytekton.com and passivehouse.us 2011):

- Designed using the Passivhaus Planning Package software
- Heating and cooling consumption $\leq$15kWh/m^2 per year (4746 btu/ft^2 per year)
- Primary Energy consumption not more than 120 kWh/m^2 per year (38.1 kBtu/sf/yr)
- Infiltration $\leq$0.6 ACH_{50} as tested with a blower door
- Specific heat load for the heating source at design temperature is recommended, but not required, to be less than 10 W/m^2 (3.17 btu/h.ft^2 per hour)

In addition to these criteria, Passive Houses usually employ simple geometry and "natural comfort" as Sam Rashkin calls passive solar. Proper solar orientation can save about 25% of home cooling and heating loads in many markets. (Rashkin 2012) The low energy requirements of a Passive House could be met with renewable energy sources to achieve a net zero energy home.

There have been active discussions of the merits and shortcomings of the Passive House Standards as applied in the United States. While most of the discussion

revolves around Passive House for colder climates (climate zones 5-8), the discussion is still relevant to North Carolina's climate. In fact, much of the discussion revolves around the application of the Passive House Standards- designed for Germany's climate- to warmer climates.

John Straube has compiled much of the criticism about the program's shortcomings (Straube 2007). Among the criticism is that the requirements are unclear or confusing, the standard disregards climate zones in its recommendations, and heating the home with ventilation air only (as recommended) is both difficult to achieve and unnecessary. Straube concludes that similar results can be achieved with less costly and environmentally impactive results than the extreme conservation measures taken by Passive House measures. Straube offers an alternative set of measures which approach Passive House results and suggests additional deployment of renewable energy generation might optimally reduce costs and negate environmental damage.

A rebuttal to Straubes criticism of Passive House standards by Rosenbaum and White (Rosenbaum and White 2009) claims that many of Straube's assumptions about the standards are wrong and that the German example of Passivhaus implementation is positive proof of the standard's effectiveness. Additionally, the standards have driven product development such that Germany now offers some of the most efficient windows and ventilation equipment. Rosenbaum and White refute Straube's criticism of cost ineffectiveness and make a compelling argument in favor of the Passive House standards. One thing that is clear from the debate surrounding Passive House is that the standards are indeed unclear and confusing as Straube claims.

4.4 PRIVATE ENTERPRISE

4.4.1 BUILDERS AND DEVELOPERS

Meritage Homes is one of the nation's largest homebuilders and has recently expanded its market in North Carolina. While other large homebuilders are designing and building Net Zero Energy homes in North Carolina, Meritage Homes is the first major production builder to offer the Net Zero Energy option. (Pettit 2012) This is a sure signal NZE homes are moving from research and development into the broader market. Meritage wants to re-envision the single family home. Taking all of the best practices available, Meritage's mission is to offer the highest value for the least dollar that allows homeowners to reach net zero. Walking into a Meritage subdivision model home, one will immediately sense this builder is different. The homes are partially deconstructed and contain truth windows to show the building features behind and within the walls. Meritage has partnered with EchoFirst Inc to provide dual solar thermal and PV to bring Meritage homes to near zero or net zero energy after loads have been reduced by about 50% by implementing envelope, lighting, and appliance improvements.

4.4.2 CONNECTING BUILDERS TO BUYERS

Without Net Zero Energy home sales, there is no market. Home sales are perhaps the most important component of NZE homes. However, states Sam Rashkin, (Rashkin 2012) "The housing industry sales infrastructure is substantially broken." He goes on, "…the housing industry does not have the skills needed to sell the compelling but invisible benefits associated with these retooled homes." His findings hold true in North Carolina where a search for EcoBroker designated real estate professionals at www.ecobroker.com revealed only 46 in the entire state. The

North Carolina Energy Efficiency Alliance (discussed earlier) focuses much of their efforts on the sales component of energy efficient homes.

Traditional home sales techniques have relied on square footage and visible amenities such as large master suites and granite counter tops. If a customer can see or feel the feature, they are more likely to have an emotional response, will value it more, and can justify paying a higher price for the home. (Rashkin 2012) However, efficient home features are often hidden or the ideas are so abstract that their value is not perceived. In order to sell efficient homes, the focus has to be on the added value. As Rashkin states, "Once Value is understood, price becomes less important."

Builders invest more in the design and construction of energy efficient homes over 'code' homes. It is reasonable that they want a return on this investment or extra value - otherwise there is no incentive to build high performance homes. However, many times builders don't see the value in their own product. In his book, Retooling the U.S. Housing Industry, (Rashkin 2012) Sam Rashkin states, "Investing additional value in more livable communities, superior quality designs, quality construction, and high performance can substantially reduce risk." Risk is reduced because high performance homes are more durable, more likely to stand the test of time, more affordable, have better indoor air quality, contain state of the art technologies, and undergo rigorous quality control. He explains how builders are losing opportunities by not building a meaningful brand for themselves built around the values listed above. Builders should own customers for life by branding their high performance homes with a 'badge of honor' that sets their home apart from others and they should back up high performance with a warranty. According to him, builders should provide homeowner education and suggest possible future upgrades. After all, the

builder maintains a stake in the home even after it is sold. The average length of home ownership is only 5 years - if after that time, the property has lost value or the homeowner is otherwise not satisfied with their high performance home, they are unlikely to purchase from that builder again.

Sales agents need to be retrained to understand and sell the value of high performance homes. They must translate features (extra insulation) into benefits (greater comfort and quieter) that the homebuyer can emotionally relate to and sell value. (Rashkin 2012) Since energy efficient home features are mostly hidden, it is dependent on the sales agent to create experiences that dramatically demonstrate why the home is superior to others. As discussed elsewhere, Meritage Homes has begun to sell this way. Their model homes are partially deconstructed and contain truth windows which visually show the superiority of the insulation.

Value needs to be recognized in the transaction process as well. Appraisers benefit from more accurate valuation of homes, mortgage lenders and insurance companies experience less risk. Homebuyers benefit from higher resale values, lower mortgage rates, and lower insurance rates. A report by the National Home Performance Council (NHPC) and the Association of Energy and Environmental Real Estate Professionals (AEEREP) (NHPC/AEEREP 2011) states that “there is a crucial lack of information (on high performance homes) that would allow markets to arrive at appropriate prices. The ideal site for this missing data to be disseminated is the nation’s set of Multiple Listing Services (MLS).” MLS are databases of information on properties that are for sale. The databases provide information on homes in a market in an organized, searchable, and user-friendly fashion for real estate agents, appraisers, and potential homebuyers. MLS listings have not typically featured

information on high performance homes such as certifications earned. MLS have been slow to incorporate such information in part because there are over 800 mostly independent MLS in the country. Only recently has this author's local MLS added HERS rating information. The NHPC/AEEREP report was created to aid in the 'greening' of MLS.

Once a database of information on green homes has been established through MLS, appraisers, mortgage lenders, and insurance agencies can research and calculate actuarially based values. However, one need not wait for the greening of over 800 MLS to come to conclusions about efficient home values. A study by the NC Energy Efficiency Alliance (Pfleger, et al. 2011) suggests that ENERGY STAR qualified homes in one North Carolina market sold for higher prices and sold in significantly shorter times compared to similar conventional homes. Other studies have come to similar conclusions in other markets in the country

Rashkin (Rashkin 2012), however, says the housing industry can't and shouldn't wait decades until all MLS are 'greened' and appraisers, lenders, and insurance industries have developed market-based responses to a new high performing product. He suggests policies to fix this market failure until information systems are in place and high performance homes can be evaluated against standard homes:

- Appraisal institutions should add the present value of the monthly energy savings based on accredited computer software calculations to the traditional appraised value.
- Lenders should provide a 0.5% interest rate discount for high performance homes.

- Insurance companies should offer a 10% discount for high performance homes.

4.4.3 PRIVATE COMPANIES

Many for-profit companies other than those already mentioned contribute to the energy efficient new home industry in North Carolina. It is estimated that there are 1,084 firms in North Carolina conducting business in the clean energy sector. (Crowley and Quinlan 2011) Charlotte, NC is being called the nation's New Energy Capital for its concentration of energy oriented organizations. (Charlotte Regional Partnership 2012) While many of these organizations are focused on traditional fuels like nuclear energy, there are also many with their sights on renewable energy and energy efficiency. The Research Triangle CleanTech Cluster is another regional initiative located in the Research Triangle Park. (Research Triangle Region 2012) There, 623 companies and a range of support organizations are accelerating economic and technological growth in smart grid, advanced transportation, and alternative energy.

4.4.4 UTILITIES

North Carolina is served by three investor-owned, regulated electric utilities and over two hundred other electric co-operative companies, municipally owned electric utilities, and other energy providers. (North Carolina Utilities Commission 2012) As it is impractical to report on all the utility's energy efficiency initiatives, this discussion will be limited to the large publicly owned utilities.

Progress Energy and Duke Energy provide electricity to the majority of the state's population. Both companies provide new homes' incentives such as reductions on

utility bills and rebates for installing high efficiency equipment. (DSIRE 2012) Progress Energy recently filed for regulator's approval of a Residential New Construction (RNC) program. (Progress Energy Carolinas 2012) This program is meant to go beyond the retired Home Advantage program, which was an effective market tool. The RNC program will include incentive tiers for homes that meet or exceed the HERO code discussed earlier under the Codes section. The top tier, if approved by the commission, would pay builders or developers $4000 for homes that met the HERO code and achieve a HERS index of 55 or less (see discussion on HERS index under the Introduction Section.) The program would also offer incentives for high efficiency HVAC cooling equipment and/or heat pump water heater. However, a builder could not take incentives for both equipment and meeting the HERO code. In addition, the program offers builders the opportunity to participate in a limited heating and cooling bill guarantee as a means of marketing the high efficient homes. Home owners must agree to use prudent energy management practices in order to participate in the bill guarantee program.

Both Duke Energy and Progress Energy also implement Demand Side Management programs. Progress Energy offers the EnergyWise program. (Progress Energy 2012) The program's objective is to reduce peak power demand through cycling air conditioner power on and off. The homeowner is offered an annual $25 credit towards their utility bill for participation in the program.

Progress Energy recently proposed a Residential Prepay Program which was subsequently denied by the Utilities Commission. (Progress Energy 2012) Under this program, Progress's customers would have prepaid for 'credit' on their electrical meter. As customers use electricity, credit is used up on the meter. Customers are

notified frequently when credit is low, and well in advance of when credit would run out. Payments to replenish credit can be made my several means including internet, smart phone, and telephone. If credit does run out, electrical service is disconnected to the home.

A previous prepay pilot by Progress Energy in 2001 concluded that prepay was well received among the participants and offered many benefits to Progress Energy including eliminating meter reading, disconnect and reconnect visits, and invoicing. (Progress Energy Service Company 2012) Among the customer reported benefits was the ability to conserve energy which was made easier by being able to monitor energy usage. Customers believed they saved money and used less electricity with the pre-pay system. Progress Energy states in their final report on the pilot program that customers used 12% less energy on the pre-pay plan. The final report to the 2001 study concludes, "The question is not whether to offer prepaid power, but when." (Progress Energy Service Company 2012) The equipment used in the 2001 study was expensive and resulting NPV was negative. The recently denied proposed prepay pilot study would have used less expensive modern smart meters and communication devices. In the Utility Commission's denial ruling, they state that Progress Energy did not supply enough information that the program was cost effective and that the ruling was without prejudice as to a future filing in which Progress Energy demonstrates that the program has the potential to be cost effective.

In June 2012, a merger proposal between Duke Energy and Progress Energy was approved. (Solano 2012) This merger would create the second largest utility in the world. Both companies tout the efficiency of scale the merger will create. However, neither company has commented specifically on how the merger will affect

incentives and pilot programs that would reduce energy use other than "New investments in technology to reduce our environmental footprint and become more efficient" (Duke Energy Corporation 2011). Several provisions of the utility council's approval of the merger have some bearing on energy efficiency in the state. The provisions do not go as far as the NCSEA had hoped when they intervened in the process. Among the provisions (Solano, Update: Duke Energy Merger Gets Greenlight 2012):

- Consider and propose for Utilities Commission approval as part of their demand-side management and energy efficiency programs specifically targeted to help low-income customers
- Contribute $2 million to NC GreenPower
- Contribute $10 million to low-income energy assistance program fund and $5 million to a community college workforce development grant fund — both of which will be administered by the Foundation for the Carolinas and the North Carolina Community Foundation

4.5 EDUCATIONAL INSTITUTIONS

4.5.1 NCSU AND NC SOLAR CENTER

North Carolina State University (NCSU) and Appalachian State University (ASU) are 2 of 17 schools in the University of North Carolina System. NCSU contributes heavily to the workforce development around solar and wind and ASU contributes to the energy efficient building design and construction workforce. While other schools contribute to the advancement of the energy efficient homes market in North Carolina, these two universities are worth singling out for their contributions.

NCSU in Raleigh, NC hosts Centennial Campus, a university research park. Within Centennial Campus are many organizations that support the energy efficiency and renewable energy industries. (North Carolina Solar Center 2012) Among them are non-profits like Advanced Energy and for profit corporations such as ABB (both discussed elsewhere) as well as governmental partners. N.C. State's Centennial Campus is a green energy "hub" for research, policy work, economic development, and workforce development. Much of the research at Centennial Campus is through the FREEDM Systems Center which focuses on smart grid technologies. Smart grids and smart meters will be the basis for an "energy internet" which will allow individual NZE homes and utilities to connect together into NZE neighbourhoods and cities. North Carolina is a leader in smart grid research and has been called the smart grid's Silicon Valley. ABB's Smart Grid Center of Excellence is a testing and demonstration centre which has a complete mock-up of a city including power poles and model house.

The North Carolina Solar Center on the NCSU campus is associated with the College of Engineering. The North Carolina Solar Center started as a high performance solar demonstration home in 1981. (Kalland 2011) It is one of the most visible and visited solar houses in the United States and has many resources on passive solar. The centre has since expanded its scope to include a spectrum of energy research and development. However, it continues to provide technical assistance, education, and support of the building industry. The Solar Center is a LEED Provider, a partner in the NC Energy Efficiency Alliance, and also administers the NC HealthyBuilt Homes Program - a certification for high performance homes delivering comfort, health, and affordability.

4.5.2 APPALACHIAN STATE

Appalachian State University in Boone, NC is also a partner in the NC Energy Efficiency Alliance through their Energy Center. (Appalachian State University Energy Center 2012) The Energy Center is an applied research and public service program through which the university makes its resources, faculty, and professional staff available to address economic, business, government, and social issues, and problems related to renewable energy policy, technology, and development.

Appalachian State University's Building Technology program has been a leading program in construction education with a focus on sustainable design and energy efficient building techniques. The diverse and comprehensive program prepares students for a variety of careers within the building industry. The Appropriate Technology program likewise prepares students for careers in renewable energy and energy management fields.

Appalachian State University also won the People's Choice Award in the Department of Energy's 2011 Solar Decathlon with their entry of The Solar Homestead. (Anna 2011) The Solar Decathlon is an international competition that challenges collegiate teams to design, build and operate energy efficient houses. Participants compete in ten categories such as market appeal, affordability, energy balance, and engineering. The Solar Homestead is a Net Zero Energy home that draws regional influence from traditional homesteads of the Appalachian Mountains.

The Center for Energy Research and Technology (CERT) at North Carolina A&T State University also deserves recognition for their research on reducing energy and water consumption and promoting sustainable energy design practices. (Center For

Energy Research and Technology 2009) The Center is currently focused on creating an energy efficient, environmentally responsible society by promoting and developing carbon dioxide emissions reduction, energy independence, and net-zero energy and sustainable design practices.

5. DISCUSSION

North Carolina, with its educational facilities, workforce, research and development areas, institutions and policies, is well poised to become a leader in both energy efficiency and renewable energy. However, of the two complementary approaches, renewable energy receives much greater attention. Energy efficient homes do not receive as generous support. While a home can install a photovoltaic electric system and receive 35% state tax credit and 30% federal tax credit, (DSIRE 2012) the largest incentive for an energy efficient home is the $4,000 utility RNC program (assuming approval from the utility commission for this proposed incentive). (Progress Energy Carolinas 2012) It will take a combined approach of energy efficiency *and* renewable energy to reduce carbon emissions and mitigate climate change. (Lovins, Amory B. and Rocky Mountain Institute 2011) Therefore, it's critical for renewable energy and energy efficiency to be evaluated on an even footing. It's easy to understand why renewable energy galvanizes our attention - attic insulation doesn't emotionally captivate us like a rooftop PV system. However, policy makers should not be led by emotions or a photo opportunity, and it is important that all parties engaged in the home construction industry are diligent in pursuing both avenues toward the development of net zero homes.

5.1 ENGAGING PEOPLE

The good news is that there is plenty in the future to get both home buyers and home builders emotionally charged up about energy efficient buildings. It is my interpretation from the considerations in the Findings section that the technology of smart meters, smart grid, and home energy monitoring and reporting, along with homeowner feedback on comfort and activities, is going to guide homes toward Net

Zero Energy. The well known adage is that what you monitor, you can manage. Homes have been and continue to be unmonitored (metered, but not monitored.) Once they are monitored and this flood of data is available, energy efficiency will be realized more easily and affordably in homes. (Pyke 2012) This, of course, should appeal to the next generation of technically savvy homebuyers. Modern communication systems and social media will make this possible. The new home industry should pay greater attention to home monitoring and reporting. Progress Energy's rejected Prepay Pilot program should be resubmitted and expanded to include more robust monitoring and reporting beyond what is just necessary to keep the lights on for the customer. Policy and incentives should also encourage the development and implementation of monitoring and reporting systems.

Fortunately, North Carolina is well placed to take the lead in reporting and monitoring. North Carolina leads in smart grid development and is headquarters for several companies focused on monitoring, analysing and reporting energy data (PlotWatt, Truveon and Eragy to name several.) Once there are data available, appraisers, mortgage lenders, and insurers can leverage this data to actuarially determine insurance rates, mortgage rates, and home prices that value high performance homes. Energy reporting will provide a large market pull (a carrot) for the efficient homes industry by making energy data (including wasted [fugitive] energy) salient. The price for fuel for our cars is advertised on big signs at gas stations. Consumers adjust behaviour to conserve gas or purchase fuel efficient cars when gas prices increase. This awareness turns to focus on home energy efficiency when gas prices increase, even though most homes don't use oil. Energy reporting through home dashboards, social media, and on smart phones and tablets will act as the billboards for home energy performance.

5.2 THE BUILDING ENCLOSURE

Home energy monitoring and reporting engages people in energy efficiency. Building efficient enclosures and efficient home design (building smart from the start) is the greatest opportunity for people to lock in efficiency at least cost. It is much costlier and more difficult to retrofit a home once it has been constructed. The Building America Program's concept of the Zero Energy Home Envelope (ZEHE) should be the eventual goal for all building codes. ZEHE's should be achievable by the 2021 code cycle. After just adopting a new code in 2012, the next cycle of NC code will take effect in 2015, the same year Building America expects to complete its ZEHE specification. While many of the features of a ZEHE may already be achieved or readily achievable in North Carolina, such as R40 ceiling assemblies, others will meet greater resistance such as 2"x6" stud walls and ducts within conditioned space.

Energy codes are a necessary market push (a stick) towards greater adoption of energy efficient homes. Along with Energy Efficiency Resource Standards and greater investment in energy efficiency programs, energy codes have been some of the most effective tools in increasing energy efficiency around the country. North Carolina should continue to lead the nation in state energy codes. Early support for more stringent energy codes, leading to ZEHE by 2021, is needed.

The current code allows a performance compliance path for homes. In a performance compliance path, trade-offs are allowed between building components in order to achieve code compliance, for example, less insulation can be traded off for greater infiltration reduction. North Carolina did away with trade-offs for high

efficiency equipment during the last code cycle, prioritizing the envelope in this sense. However, reduced insulation levels are still possible, as in the example trade-off given above. Thus, reduced insulation levels that have not been optimized can be traded off. It is my opinion that insulation values should not be traded off with non-insulation components such as infiltration. Insulation levels should only be allowed to be traded off with insulation levels elsewhere. This would allow for visual or structural design considerations in buildings. For example, a decorative uninsulated concrete wall could be allowed only if insulation values elsewhere (such as ceiling) were increased. On the positive side, trade-offs are allowed with passive solar practices such as added thermal mass and concentrating windows on the south side (north in the southern hemisphere), thus incentivising passive solar design.

Progress Energy's new incentive appears to slightly favour equipment efficiency over building envelope improvements (taking into account relative costs associated with meeting the various incentives.) The equipment efficiency incentive (the lowest tier of new incentives) has done away with the requirement that a home also meet the ENERGY STAR for new homes program. That requirement ensured that envelope improvements were addressed in order to receive incentives for high efficiency equipment. Also, there are some expected "free rider" effects of the incentive - builders building to a higher energy standard regardless of the incentive will take advantage of it. The NC REPS appears to be the driver behind Progress Energy's generous HERO code incentives. Through the payment of incentives and other considerations to homeowners through the incentive, Progress Energy is "entitled to any and all environmental, energy efficiency, demand reduction benefits, and attributes, including all reporting and compliance rights, associated with participation in the program." (Progress Energy Carolinas 2012) The REPS can certainly be

credited for much of the growth in the renewable energy industry since its adoption. However, in a recent ACEEE report, North Carolina's REPS (specifically the EERS portion) ranked near the bottom in a comparison of 24 other states with energy efficiency resource standards. (Sciortino, et al. 2011)

With the exception of some custom builders, the approach most builders take towards energy efficiency in homes seldom addresses design changes. As mentioned in the Findings, homes built to Passive House standards employ simple geometry and passive solar design out of necessity because it is recognized that these techniques are efficient in reducing heating, cooling, and lighting loads. Passive House standards do not require these techniques. The NC Solar Center promotes such design, but the author does not know of any programs or incentives at the state or federal level which incentivises or requires such design considerations. "Natural comfort" (to use Sam Rashkin's term) design is best put into practice at the land development planning phase. By designing predominantly east-west streets, south oriented homes (north in the southern hemisphere) are encouraged. Promotion of these practices would fall under zoning and planning regulations.

5.3 ENERGY STAR

The ENERGY STAR for new homes program has been an important accelerator of energy efficient homes in the state. However, as mentioned in the Findings, ENERGY STAR has met with resistance and is falling out of favour. Builders are opting for programs which are less stringent and Progress Energy has eliminated ENERGY STAR from its incentive program. This is unfortunate for the efficient homes industry for a couple of reasons: 1) it turns a blind eye to building science, 2) it returns to a mentality of "brute force" rather than systems thinking, and 3) there

need to be assurances that nothing has been sacrificed in the home at the expense of efficiency. These will be discussed in order.

1) The ENERGY STAR guidelines are a result of rigorous research into energy efficient buildings and why they fail or work. Building science has taught us that there are consequences to increasing efficiency in buildings such as decreased ability for building assemblies to dry out (try blow drying your hair through a piece of insulation). Research into existing homes has proven that one of the primary failures in existing homes is rot resulting from water intrusion. Yet one of the most contested additions to the new ENERGY STAR guidelines is the Water Management Checklist which was designed to keep buildings dry and durable. Efficiency programs that ignore the laws of building science and hope to gain efficiency through "brute force" (ever greater levels of insulation) do a disservice to the industry.
2) Many homes are built without regard to passive solar design considerations (as discussed above): Large window areas, no overhangs, no regard for orientation. The only solution to heating and cooling these homes is "Brute Force" as Sam Rashkin puts it. (Rashkin 2012) On the other hand, systems design (integrative design as Amory Lovins calls it) (Lovins, Amory B. and Rocky Mountain Institute 2011) is the consideration of the building as a whole series of inter-related components where changes in one component have an effect on other components. One example of integrative design from Amory Lovins involves the Empire State Building in New York City, but is also applicable to residential construction. Replacing the windows with high efficiency double pane windows cut building heating and cooling loads significantly. This allowed renovating and reducing the existing chillers rather than replacing them (which would have involved Excavating Fifth

Avenue.) Integrative design needs to be encouraged. ENERGY STAR guidelines have been developed with integrative design in mind. Other programs that attempt efficiency through brute force (increased insulation, decreased duct and infiltration) leave many options on the table.

3) The belief that efficiency alone will attract homebuyers to homes is false. The Yugo was an efficient car for its time (1980's) getting around 28 to 29 miles per gallon. However, it was an utter failure because it lacked performance, needed frequent repair, and was costly to repair among many other problems. Focusing on efficiency alone would be to build the Yugo of homes. ENERGY STAR labels do not compromise energy efficiency for a lower quality. ENERGY STAR labelled light bulbs, for example, require minimum specifications for lumen maintenance, lifetime, starting time, warm up time, warranty, and safety just to mention a few of the non-energy-related requirements. It was recognized that an inferior product, even if it were more efficient, would give the industry a black eye. The solar thermal industry is just now recovering from the black eye it suffered in the 70's when unscrupulous installers took advantage of the energy crisis and installed inferior systems that failed. The efficient homes market does not need any black eyes. ENERGY STAR homes deliver a minimum assurance that nothing has been sacrificed in delivering energy efficiency in the home- not durability, not indoor air quality, not safety. ENERGY STAR homes deliver a Prius of a home, not a Yugo.

5.4 LIGHTS AND APPLIANCES

Typically, states hold off on any action concerning lights and appliances (L&A) efficiency while federal standards are under review, such is the current state of lights

and appliances efficiency. It is unlikely that North Carolina will pursue any lights and appliances efficiency standards at this time. Utility incentives for L&A have basically remained unchanged for some time. Progress Energy's proposed RNC Program simply raises the efficiency requirement for air-conditioners and heat pumps from a sub-ENERGY STAR level to one that now meets ENERGY STAR. Support for lights and appliances efficiency ought to be at the federal level. From reviewing Passivehaus standards and personal experience abroad, the United States ought to look for guidance from overseas. For instance, the Passivehaus standard has helped drive development of highly efficient equipment in Germany.

5.5 Renewable Energy

Getting new homes to net zero energy will firstly require engaging people, addressing a broader "profoundly broken" (Rashkin 2012) housing industry, locking in efficiency with efficient enclosures, and then utilizing efficient lights and appliances. Such a home will be optimized for renewable energy to meet the remaining loads. Throughout the process, integrative design should be employed to maximize the benefits from all expenditures.

Renewable energy is well supported in North Carolina when compared to energy efficient support in the state. However, there is still work to be done. Many of the policies that support renewable energy could be strengthened such as the net-metering law that received a score of 'F' by renewable energy industry experts. Renewable energy also requires stable federal support. Not only should renewable energy be considered on an even footing with energy efficiency, but also with fossil fuels. Fossil fuels and nuclear energy receive support that is not necessary for such an established industry.

New homes can lock in the future addition of renewable energy. Solar ready homes should be promoted in the state. Solar ready homes are designed with adequate roof area and orientation for solar, as well as dedicated conduits for connecting solar equipment. It is worth repeating here that North Carolina is poised, with all its support organizations and mechanisms, to be a leader in renewable energy.

6. CONCLUSIONS

The growth of energy efficient homes in North Carolina has thus far developed without much market intervention. However, in order to mitigate climate change, homes will need to realize substantial reductions in energy consumption. This will necessitate some market intervention. North Carolina is in a great position to capitalize on its existing workforce, institutions, and organizations to be a leader in energy efficient homes. However, policies, incentives, and resources now are heavily skewed towards support for renewable energy. Energy efficiency and renewable energy should be considered on an even footing. But, in North Carolina, renewable energy has the leg up.

7. RECOMMENDATIONS

In order to support the construction of high performance efficient homes and bring it on an even footing with renewable energy, it will be necessary to expand and strengthen what has worked thus far:

- Support the ENERGY STAR for new homes program through education, promotion, and incentives. Return to efficiency guided by solid building science, integrative design, and assurances of quality.
- Continue to strengthen the North Carolina energy code to keep it one of the strongest in the nation. Eliminate trade-offs that do not prioritize the building enclosure. Aim for Zero Energy Home Enclosures as code in 2021.
- Expand and strengthen the Energy Efficiency portion of the NC Renewable and Energy Efficiency Portfolio Standard. A stand alone Energy Efficiency Resource Standard would have greater status, show commitment to energy efficiency as a first new energy source, and help put it on an even footing with renewable energy.
- Refine Progress Energy's proposed Residential New Construction incentives. Equipment rebate should require ENERGY STAR label and ENERGY STAR installation practices at a minimum (proper sizing, tight ducts, proper charge, and correct air flow.) Incentives for efficient homes should be based on ENERGY STAR for new homes, not HERO code.

In addition, the following support should be considered in the areas where there is now little or no involvement:

- Develop and fund energy efficiency programs or incentives aimed at the residential market, such as home tax credits, that put efficiency on an even footing with renewable energy.

- Increase code enforcement and compliance.
- Increase federal and state support for energy efficient lights, appliances, and equipment such as increased efficiency standards, rebates, or tax credit.
- Develop appraisal, lender and insurance policies that value high performance homes over standard homes.
- Encourage a state-wide 'greening' of the MLS

The NC Sustainable Energy Association and the NC Solar Center have the resources and experience to support and promote these recommended policies. There is no shortage of workforce in North Carolina, and North Carolina has schools and community colleges that are already providing the education. Innovation comes from North Carolina's energy hubs around Charlotte and the Research Triangle Park and NC universities. Federal R&D and demonstrations through Building America and other organizations will continue to develop best practices for building and designing energy efficient homes. Programs are already in place such as ENERGY STAR, HERO code, and Passive House Standard. By all accounts, North Carolina is poised to supply a market with high performance energy efficient homes, and valuing energy efficiency on an even footing with renewable energy in the state can create that market.

This compendium succeeds in providing an overview of and insight into the support for energy efficient new homes construction in North Carolina. Additionally, drivers and barriers to energy efficient homes gaining market share in North Carolina have been identified. Suggestions have been given on what can contribute to the greater adoption of energy efficient homes in North Carolina. The research questions which were set out in the Introduction Section have been answered. It is the author's hope

that these results will lead to a significant increase in efficiency in new homes and a greater market penetration of energy efficient new homes. Net zero energy homes are still rare in North Carolina, but they are market ready.

8. WORKS CITED

Advanced Energy. “SystemVision Great Standards for Living.” *Advanced Energy.* http://www.advancedenergy.org/buildings/knowledge_library/systems_approach/systemvision/index.html (accessed July 17, 2012).

Advanced Energy. “Welcome.” *Advanced Energy.* 2012. http://www.advancedenergy.org/ (accessed July 17, 2012).

American Wind Energy Association. “Production Tax Credit (PTC).” *American Wind Energy Association Web site.* April 2011. http://awea.org/issues/federal_policy/upload/PTC_April-2011.pdf (accessed June 24, 2012).

Anchorage Building Corp. *Anchorage Building Corp.* 8 July 2012. http://www.anchoragebuildingcorp.com/ (accessed July 17, 2012).

Anderson, R., and D. Roberts. *Maximizing Residential Energy Savings: Net Zero-Energy Home Technology Pathways.* Technical Report, Golden: National Renewable Energy Laboratory, 2008.

Anna, Carol. *Appalachian State Wins People's Choice Award.* 11 October 2011. http://www.solardecathlon.gov/blog/archives/1926 (accessed July 17, 2012).

Appalachian State University Energy Center. *Appalachian State University Energy Center.* 2012. http://energy.appstate.edu/ (accessed July 17, 2012).

Atlantic Marine Corps Communities. *AMCC Constructs First Net Zero Energy Home on a Mainland Marine Corps Installation.* http://www.atlanticmcc.com/Camp-Lejeune---New-River/Community-Information/News-Archive/News/Net-Zero-Energy-Home (accessed July 17, 2012).

Building America. *About Building America.* 18 October 2011. http://www1.eere.energy.gov/buildings/building_america/about.html (accessed June 20, 2012).

Center For Energy Research and Technology . *Center For Energy Research and Technology - Intro to CERT.* 2009. http://cert.ncat.edu/ (accessed July 17, 2012).
Charlotte Regional Partnership. *Charlotte USA - The New Energy Capital.* 2012. http://charlotteusa.com/news-media/the-new-energy-capital/ (accessed July 17, 2012).

ClimateBites. *Climate Change as a Threat Multiplier.* http://www.climatebites.org/component/content/article/35-climate-communication-tools/climate-change-narratives/54-climate-change-as-a-threat-multiplier (accessed July 16, 2012).

Cohen, Bennett. *Yahoo! Green.* 8 December 2008. http://wb.green.fy3.b.yahoo.com/blog/amorylovins/70/remodeling-amory-lovins-

home.html;_ylt=AiBCd60SQANjWesYb6CxLwGVV8cX (accessed March 11, 2012).

Crowley, Rich, and Paul Quinlan. *North Carolina Renewable Energy & Energy Efficiency Industries Census 2011.* Census, Raleigh: NC Sustainable Energy Association, 2011.

DSIRE. "North Carolina Incentives/Policies for Renewables & Efficiency." *DSIRE Web site.* 2012. http://www.dsireusa.org/incentives/index.cfm?re=0&ee=0&spv=0&st=0&srp=0&state=NC (accessed July 16, 2012).

Duke Energy Corporation. "Merger Fact Sheet." *Duke Energy Web site.* 2011. http://www.duke-energy.com/progress-energy-merger/assets/pdfs/Duke-Progress-Merger-Fact-Sheet.pdf (accessed May 8, 2012).

Easley, Gov. Michael F. "GOV. EASLEY ANNOUNCES STATE RECEIVES FEDERAL ENERGY GRANT." *NC Department of Administration.* 9 September 2008. http://www.doa.nc.gov/media/releases/showrelease.asp?id=0001-10SEP08 (accessed July 17, 2012).

ENERGY STAR. *For New Home Industry Professionals.* http://www.energystar.gov/index.cfm?c=bldrs_lenders_raters.pt_bldr (accessed July 17, 2012).

ENERGY STAR. *New Homes Partners in North Carolina.* http://www.energystar.gov/index.cfm?fuseaction=new_homes_partners.showStateResults&s_code=NC (accessed July 17, 2012).

Everett, Bob. "Solar Thermal Energy ." In *Renewable Energy: Power for a Sustainable Future*, by Godfrey Boyle, 17-64. Oxford: Oxford University Press, 2004.

Farhar, Barbara C. "Advancing a Market for Zer-Energy Homes." *Solar Today*, January/February 2008: 24-29.

Gunther, Marc. "Why Efficiency is Smarter Than Renewables." *BreenBiz Web site.* 15 June 2012. http://www.greenbiz.com/blog/2012/06/15/why-efficiency-smarter-renewables?page=0%2C0&utm_source=twitterfeed&utm_medium=twitter&utm_campaign=greenbuzz (accessed June 30, 2012).

Harkrader, Richard. "Net Metering Comes to North Carolina!" *Carolina Sun*, Fall 2005: 1.

Jespersen, Andreas Maaløe. *iNudgeyou: Green Nudge: The Wattson clock cuts your electricity bill with style.* 8 February 2012. http://inudgeyou.blogspot.com/2012/02/green-nudge-wattson-clock-cuts-your.html (accessed June 6, 2012).

Johnson Controls and International Facility Management Association. "Building Efficiency." *EnergyBiz*, July/August 2010: 48.

Johnston, David, and Scott Gibson. *Toward a Zero Energy Home.* Newtown: The Taunton Press, 2010.

Kalland, Steve. *NCSU Solar House Celebrating 30 Years!* 2011. http://ncsc.ncsu.edu/index.php/resource-center-2/solar-house/ (accessed July 17, 2012).

Lovins, Amory. *Amory Lovins: Don't Suppress Military-Led Innovation.* 18 June 2012. http://blog.rmi.org/blog_Amory_Lovins_Dont_Suppress_Military_Led_Innovation (accessed June 25, 2012).

Lovins, Amory B. and Rocky Mountain Institute. *Reinventing Fire.* White River Junction: Chelsea Green Publishing Company, 2011.

Maines, Michael. "The Pretty Good House: Finding the Right Balance Between Construction Cost and Energy Performance." *GreenBuildingAdvisor.com.* 6 February 2012. http://www.greenbuildingadvisor.com/blogs/dept/guest-blogs/pretty-good-house (accessed March 29, 2012).

Mapawatt. *Climate Zones and Degree Days.* 19 November 2010. http://mapawatt.com/2010/11/19/climate-zones-and-degree-days/ (accessed April 13, 2012).

Mathis, R. Christopher. "North Carolina Has a New Energy Conservation Code!" *Mathis Consulting.* 24 June 2011. http://www.mathisconsulting.com/storage/NC%20Energy%20Code%20Passed%20-%2006242011%20Release.pdf (accessed July 17, 2012).

NC Energy Efficiency Alliance. "About the Alliance." *NC Energy Efficiency Alliance.* 2012. http://ncenergystar.org/about/about-alliance (accessed July 17, 2012).
NC GreenPower. "About NC GreenPower > Program Overview." http://ncgreenpower.org/about/ (accessed July 17, 2012).

NC Sustainable Energy Association. *A Citizen's Guide - North Carolina Renewable Energy and Energy Efficiency Portfolio Standard.* Informational Guide, Raleigh: NC Sustainable Energy Association, 2012.

NC Sustainable Energy Association. "NC Sustainable Energy Association." *NC Sustainable Energy Association.* 2012. http://energync.org/assets/files/NCSEA-Flyer2.pdf (accessed July 17, 2012).

NHPC/AEEREP. "Unlocking the Full Value of Green Homes." *EcoBroker web site.* 2011. https://www.ecobroker.com/userdef/Green%20MLS.pdf (accessed June 29, 2012).

North Carolina General Assembly. "Performance Standards for Sustainable, Energy-Efficient Buildings ." *North Carolina General Assembly Enacted Legislation.* http://www.ncga.state.nc.us/EnactedLegislation/Statutes/pdf/ByArticle/Chapter_143/Article_8C.pdf (accessed July 17, 2012).

North Carolina Solar Center. *Partnerships.* 2012. http://ncsc.ncsu.edu/index.php/about-ncsc/partners-outreach/ (accessed July 17, 2012).

North Carolina Utilities Commission. *Industries Regulated by the Commission.* 2012. http://www.ncuc.commerce.state.nc.us/industries/industries.htm (accessed July 17, 2012).

Pettit, Katherine. *The Net Zero Home is Here!* 2012. http://www.carolinaliving.com/green/net-zero.asp (accessed June 18, 2012).

Pfleger, William, Jeff Tiller, Chuck Perry, and Nicholas Hurst. "Market Impacts of ENERGY STAR Qualification for New Homes." *NC Energy Efficiency Alliance* . 2011. http://ncenergystar.org/sites/ncenergystar.org/files/NCEEA_ENERGY_STAR_Market_Impact_Study.pdf (accessed June 29, 2012).

polytekton.com and passivehouse.us. *What is a Passive House?* 2011. http://www.passivehouse.us/passiveHouse/PassiveHouseInfo.html (accessed May 30, 2012).

Progress Energy Carolinas. "Petition for Approval of Residential New Construction Program." *North Carolina's Utilities Commission.* 31 May 2012. http://ncuc.commerce.state.nc.us/cgi-bin/webview/senddoc.pgm?dispfmt=&itype=Q&authorization=&parm2=ZAAAAA35121B&parm3=000138955 (accessed June 26, 2012).

Progress Energy. *Energy Wise Home Program.* 2012. https://www.progress-energy.com/carolinas/home/save-energy-money/energy-efficiency-improvements/energy-wise/energywise-home-25.page (accessed July 17, 2012).

Progress Energy. *PEC's Residential Prepay Pilot Program Schedule RPP-18.* 17 February 2012. http://ncuc.commerce.state.nc.us/cgi-bin/webview/senddoc.pgm?dispfmt=&itype=Q&authorization=&parm2=WAAAAA15021B&parm3=000137093 (accessed July 17, 2012).

Progress Energy. "PEC's Response to 4/24/12 Order." *North Carolina Utilities Commission Web site.* 4 May 2012. http://ncuc.commerce.state.nc.us/cgi-bin/webview/senddoc.pgm?dispfmt=&itype=Q&authorization=&parm2=EBAAAA52121B&parm3=000137093 (accessed May 8, 2012).

Pyke, Chris. *Accelerating Green Building Market Transformation.* 16 March 2012. http://www.greenbiz.com/video/2012/04/06/usgbc-chris-pyke-green-building-market-transformation (accessed July 16, 2012).

Randazzo, Ryan. *Testing Today's Efficient Homes.* 5 May 2012. http://www.usatoday.com/USCP/PNI/Business/2012-05-05-PNI0505biz-efficientPNIBrd_ST_U.htm (accessed July 16, 2012).

Rashkin, Sam. *Retooling the U.S. Housing Industry.* Clifton Park: Delmar, Cengage Learning, 2012.

Research Triangle Region. *Cleantech.* 2012. http://www.researchtriangle.org/clusters/cleantech (accessed July 17, 2012).

RESNET. "2006 Mortgage Industry National Home Energy Rating Systems Standards." *RESNET Web site.* 2 March 2012. http://www.resnet.us/standards/RESNET_Mortgage_Industry_National_HERS_Standards.pdf (accessed July 16, 2012).

Rosenbaum, Marc, and David White. "In Defense of the Passive House Standard." *Green Building Advisor.* 14 October 2009. http://www.greenbuildingadvisor.com/blogs/dept/green-building-blog/defense-passive-house-standard (accessed June 6, 2012).

Sciortino, Michael, et al. "The 2011 State Energy Efficiency Scorecard." *American Council for an Energy Efficient Economy (ACEEE) web site.* October 2011. http://www.aceee.org/sites/default/files/publications/researchreports/e115.pdf (accessed June 30, 2012).

Solano, Amneris. "Update: Duke Energy Merger Gets Greenlight." *NC Sustainable Energy Association Web site.* 2 July 2012. http://energync.org/blog/ncsea-news/2012/07/02/update-duke-energy-merger-gets-greenlight/ (accessed July 3, 2012).

State Climate Office of North Carolina. *Aspects of NC Climate- Overview.* http://www.nc-climate.ncsu.edu/climate/ncclimate.html (accessed April 15, 2012).

Straube, John. "The Passive House (Passivhaus) Standard - A comparison to other cold climate low-energy houses." *buildingscience.com.* 7 September 2007. http://www.buildingscience.com/documents/insights/bsi-025-the-passivhaus-passive-house-standard (accessed May 31, 2012).

Tomasulo, Katy. *Boomers, Gen Y, Immigrants to Shape Housing Demographics.* 6 November 2009. http://www.ecohomemagazine.com/news/2009/11/boomers-gen-y-immigrants-to-shape-housing-demographics.aspx?printerfriendly=true (accessed July 16, 2012).

U.S. Census Bureau. *U.S. Census Bureau: State and County QuickFacts.* 17 January 2012. http://quickfacts.census.gov/qfd/states/37000.html (accessed April 13, 2012).

U.S. Department of Energy Building Energy Codes. *2010 Building Energy Codes Annual Report.* Annual Report, Building Energy Codes, 2011.

U.S. Department of Energy. *DOE Challange Home Guidelines to Meet the NEW Challange.* 15 May 2012. http://www1.eere.energy.gov/buildings/challenge/bcqc_criteria_glance.html (accessed July 16, 2012).

—. "Residential Prescriptive Requirements 2009 IECC." *Building Energy Codes Program.* http://energycode.pnl.gov/EnergyCodeReqs/index.jsp?state=North%20Carolina (accessed July 16, 2012).

U.S. Environmental Protection Agency. *Executive Order 13514.* 16 August 2011. http://www.epa.gov/oaintrnt/practices/eo13514.htm (accessed July 17, 2012).

Yi, Aris, Samuel Ramirez, and Michael Bendewald. *Lovins GreenHome 1.0 Factor Ten Engineering Case Study.* White Paper, Snowmass: RMI, 2010.